Feasibility Evaluation of Downhole Oil/Water Separator (DOWS) Technology

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Executive Summary

The largest volume waste stream associated with oil and gas production is produced water. Treatment and disposal of produced water represent significant costs for operators. A relatively new technology, downhole oil/water separators (DOWS), has been developed to reduce the cost of handling produced water. DOWS may also be referred to as DHOWS or as dual injection and lifting systems (DIALS). DOWS separate oil and gas from produced water at the bottom of the well and reinject some of the produced water into another formation or another horizon within the same formation, while the oil and gas are pumped to the surface. Since much of the produced water is not pumped to the surface, treated, and pumped from the surface back into a deep formation, the cost of handling produced water is greatly reduced. When DOWS are used, additional oil may be recovered as well. In cases where surface processing or disposal capacity is a limiting factor for further production within a field, the use of DOWS to dispose of some of the produced water can allow additional production in that field. Simultaneous injection using DOWS has the added benefit of minimizing the opportunity for contamination of underground sources of drinking water through leaks in tubing and casing during the injection process. Similar devices have been used to a much greater extent for downhole gas/water separation. However, this report is limited to discussion of oil-water separators.

Two basic types of DOWS have been developed - one type using hydrocyclones to separate oil and water and one relying on gravity separation. Hydrocyclone-type DOWS can handle larger flow volumes than gravity separator-type DOWS but are significantly more expensive. Several alternative designs of DOWS are available from different vendors. Hydrocyclones have been paired with electric submersible pumps, rod pumps, and progressing cavity pumps, while gravity separator-type DOWS have utilized only rod pumps. In order to fit into 5.5-inch or 7-inch casings, DOWS are designed as long, slender tools.

Most DOWS installations have been set up with the producing zone above the injection zone. VOWS can potentially be used for waterflooding. DOWS could also be used for reverse coning to reduce the degree of water influx into oil-producing zones.

Conversion of a well from a regular pump to a DOWS is a relatively expensive undertaking. Total costs include the DOWS tool itself and well workover expenses. Costs for the hydrocyclone-type DOWS are fairly high. For example, the cost of an electric submersible pump-based DOWS system is approximately double to triple the cost of replacing a conventional electrical submersible pump and is often in the range of $90,000 - $250,000, excluding the well workover costs, which can often exceed $100,000. Costs are somewhat lower for the gravity separation-type DOWS, ranging from $15,000 - $25,000, and the cost of a complete gravity separator-type DOWS installation was $140,000 Canadian (Reid 1998).

DOWS installations will not necessarily be cost-effective for all wells. Knowledge of the reservoir and historical production are important before selecting a DOWS installation. The characteristics of wells that are likely to work well with DOWS include, among others, a high water-to-oil ratio, the presence of a suitable injection zone that is isolated from the production zone, compatible water chemistry between the producing and injection zones, and a properly constructed well with good mechanical integrity. DOWS installations in wells that meet these requirements must still remain in good operating conditions for long enough that the accrued monthly savings can offset the initial purchase costs of the equipment. The track record of existing installations is mixed, with some DOWS remaining in service for more than two years but with others failing within a few days. This situation is understandable given that fewer than 40 DOWS have been installed in North America through mid-1998. The technology is new and is still being refined and improved with each successive installation.

This report includes information on 37 DOWS installations in North America. Key statistics from that set of data include:

- More than half of the installations to date have been hydrocyclone-type DOWS (21 compared with 16 gravity separator-type DOWS).

- Twenty-seven installations have been in Canada and ten installations have been in the United States.

- Of the 37 DOWS trials described in this report, 27 have been installed in four producing areas - southeast Saskatchewan, east-central Alberta, the central Alberta reef trends, and East Texas.

- Seventeen installations were in 5.5-inch casing, 14 were in 7-inch casing, I was in 8.625-inch casing, and 5 were unspecified.

- Twenty of the DOWS installations have been in wells located in carbonate formations and 16 in wells located in sandstone formations. One trial did not specify the lithology. DOWS appeared to work better in carbonate formations, showing an average increase in oil production of 47% (compared with an average of 17% for sandstone formations) and an average decrease in water brought to the surface of 88% (compared with 78% for sandstone formations)

- The volume of oil increased in 19 of the trials, decreased in 12 of the trials,- stayed the same in 2 trials, and was unspecified in 4 trials. The top three performing hydrocyclone- type wells showed oil production increases ranging from 45 7% to 1, 162%, while one well lost all oil production. The top three gravity separator-type wells showed oil production increases ranging from 106% to 233%, while one well lost all oil production.

- All 29 trials for which both pre-installation and post-installation water production data were provided showed a decrease in water brought to the surface. The decrease ranged from 14% to 97%, with 22 of 29 trials exceeding 75% reduction.

- The data on injectivity and the separation distance between producing and injection formations do not correlate well with the decrease in water volume brought to the surface.

Some of the installations experienced problems that impeded the ability of the DOWS to function properly. At least two installations suffered from low injectivity of the receiving zone; in both cases, incompatible fluids contacted sensitive reservoir sands, which plugged part of the permeability. Several installations noted problems of insufficient isolation between the producing and injection zones. If isolation is not sufficient, the injectate can migrate into the producing zone and then short-circuit into the producing perforations. The result will be recycling of the produced water, with oil production rates dropping to nearly zero. Other DOWS have been plugged by fines or sand. Several trials were canceled prematurely because of corrosion and scaling problems. Finally, some of the early installations suffered from poor design features.

Because the technology is still new, no regulatory requirements for DOWS exist in many jurisdictions. The U.S. Environmental Protection Agency (EPA) does not now have a formal position on how to regulate DOWS. Four states (Colorado, Oklahoma, Louisiana, and Texas) have developed either regulations or administrative guidelines for DOWS. Those states regulate DOWS with requirements comparable to or less stringent than those for regular Class 11 injection wells. There is some concern that EPA might decide that DOWS are not covered under the definition of a Class U well, thereby potentially leading to stricter requirements that could hinder future use of DOWS. It is important for EPA and state regulators to develop reasonable regulatory requirements for DOWS in order not to impede their use in the future.